# Membrane Separators for Water

For Each Topic Discuss How it works, Advantages and Drawbacks and give a quantitative analysis of how much would need to be sent up in initial supply.

## Reverse Osmosis:

Reverse osmosis works by separating two solutions by a semi-permeable membrane and pressure is supplied to reverse the natural flow of the water. This ensures the water moves from the more concentrated solution to the weaker solution and thus the contaminants end up on one side of the membrane and water on the other. The main difference between reverse Osmosis and Filtration is that reverse osmosis success is dependent on the solute concentration and flux rate. It is commonly used for obtaining drinking water.

Disadvantages: There are some drawbacks however, which make it an inefficient means of purifying drinking water. This is due to the fact that the small pores in the membrane can block particles with large molecular structures such as salt, but those with smaller molecules than water, such as chlorine, are able to seep through. This means that water used for laundry etc might not be able to be recycled if they contain chemicals with are able to travel through the membrane into the water solute and lead to harmful drinking water. In order to combat this a carbon filter needs to be added, which increases the price of reverse osmosis however increases its potability.

Another drawback is due to the fact that when the water is passed through the membrane, healthy nutrient factors of the water can be removed and so the drinking water obtained is not containing all the nutrients the members of the space crew need from drinking water, thus it is not achieving its central purpose. The water could be used for washing and cleaning but it would make sense to have a recycling procedure for water that is able to produce drinking, washing and laundry water.

The water would need to go through a magnesium and calcium mineral bed in order to obtain minerals for drinking water; it will also increase the pH and decrease corrosive abilities on the water.

Reverse Osmosis can also waste a large portion of the water. For example for every gallon of purified water, generally two to three gallons of water are wasted. This is not efficiently recycling the water placed on board to begin with and so a more efficient process that wastes much less water should be considered. The process is also slow which wouldn’t be a huge drawback if the required water is produced but with all factors considered it seems an alternative would be more appropriate on board the ISS.

So Quantitatively, in order to obtain 17472 kg of drinking water approximately 43680 kg is wasted, and the water is probably too unsanitary to be reused for cleaning or laundry again. This is approximately 40 % efficient. Although no space system is 100% it is possible to achieve conversions of above 90% and so it seems this method can be disregarded.

At 40% efficient the results are as followed:

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| If 82362.75 kg water is initially Supplied and 254.3 kg a day is used up and needing recycled | |
| Amount Recycled a day: 101.68 kg | Total Amount Recycled:  54907.2 kg |
| Amount Initially Supplied: 82363.75 | Total amount for Journey: 137270.95 kg |
| So To conclude. If the Process is 40% efficient and for example a days worth of water is recycled everyday, Then it would take an initial supply of 82363.75 kg of water to be initially supplied in order to obtain the required amount for the journey. | |
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## Nanofiltration- An emerging Contender

Nanofiltration membranes have filters with a pore size approximately 0.001 microns and is able to remove most organic matter and nearly all viruses. They are created in several different designs. Spiral-wound membranes roll up many layers of flat membrane sheets that are centered on a pipe that supplies the water that is required to be treated. This type of membrane separation is subject to physical limitations, like the water that is filled with particulates can clog membranes and the system produces large volumes of concentrate, which needs to be disposed of.

Nano filtrations require very high water pressures in order to force the water through extremely small pores. It is able to remove water hardness, natural organic matter and synthetic organic chemicals from water. However it is required that the source water is treated prior to Nano filtration, which means that the process is more expensive. Like reverse osmosis the membrane also needs periodic removal and cleaning.

Nanofiltration operates between 85 and 95% (according to <http://www.membranes-amta.org/amta_media/pdfs/3_NF_RO.pdf>). So already more efficient than reverse osmosis, using 90% as an example:

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| --- | --- | --- |
| NanoFiltration | so again 254.3 kg a day used and needing recycled. | |
| Amount initially Supplied: 13727.125 kg | Amount Recycled per Day: 228.87kg | Total Amount Recycled: 123589.8 kg |
| Total Amount of water Obtained: 137316.925kg  So To conclude. If the Process is 90% efficient and for example a days worth of water is recycled everyday, Then it would take an initial supply of 13727.125 kg of water to be initially supplied in order to obtain the required amount for the journey. | | |

This is approximately 17% of the amount that would need to be initially supplied for reverse osmosis.

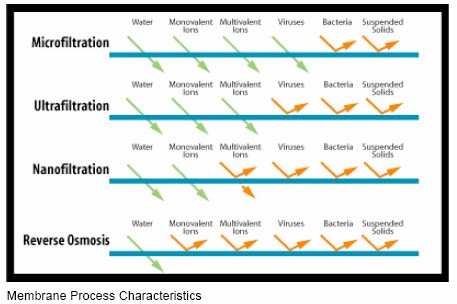
## Electrodialysis/Electrodialysis Reversal

Another form of membrane separation is the Electrodialysis and Electrodialysis reversal treatment systems. These use electricity and a series of membranes to separate salts from the water and concentrates them into a solution for disposal.

When dealing with organic water compounds and microbes the negative ions are pulled to one side and the positive ions are pulled to another, a channel then occurs where they pass through the membranes are and disposed of. Because only the ions and not the source water directly travel through the membranes not all contaminants are removed. In order to obtain a more pure solution they are prefiltered. The system uses large amounts of energy in order to produce the constant current that drives the purification. They are commonly used for obtaining ultra pure water. Typically Efficiencies range about 70-80% (<http://www.eetcorp.com/lts/graph_HEED1.htm>) and so using an example of 75%.

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| Electrodialysis |  |  |
|  |  |  |
| Amount Initially Supplied: 34317.81 kg | Amount Recycled per day: 190.725 kg | Total Amount Recycled: 102991.5kg |
| Total Amount obtained: 137309.31 kg |  |  |

If the Process is 75% efficient and for example a days worth of water is recycled everyday, Then it would take an initial supply of 34317.81 kg of water to be initially supplied in order to obtain the required amount for the journey.



**Figure 1: Diagram of what the Membranes Remove**

(<http://www.safewater.org/PDFS/resourcesknowthefacts/Ultrafiltration_Nano_ReverseOsm.pdf> - accesssed 31st December 2011)

Conclusion

* From the Quantitative analysis and overall advantages and drawbacks it seems out of the options for membrane separation Nano Filtration is the most ideal solution in terms of efficiency.
* However Reverse Osmosis technology is a tried and tested method and if an efficient membrane is used, and the water that passes through the membrane can be pumped up to be treated again the efficiency may be increased. Also when passed through a mineral bed it can obtain the require minerals for healthy drinking water.
* Due to Nano filtration being the most efficient, it requires the least amount of water sent up in the initial supply, which in turn will save money.
* A comparison between whether reverse osmosis or Nano filtration produces the correct composition of water needs to be investigated.

Re-Supply

* Membranes can last up to 5 years and so would not need re supplied within the 18 months
* Provided the initial amount is supplied more water would not need to be resupplied…not sure if amount is feasible or not?